United States Patent [19]

Lanker

[11] **3,916,269**

[45] **Oct. 28, 1975**

[54] **CHARGING DEVICE**

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Feb. 9, 1973 Switzerland 001938/73

[52] **U.S. Cl.** .... **317/262 A**

[51] **Int. Cl.²** **H01T 19/00**

[58] **Field of Search** .... 317/262 A; 250/324–326

[56] **References Cited**

UNITED STATES PATENTS

3,163,753	12/1964	Di Sabato et al.	317/262 A
3,303,401	2/1967	Naumann et al.	250/324
3,611,074	10/1971	Weichardt	317/262 A
3,656,021	4/1972	Furuichi et al.	317/262 A
3,800,153	3/1974	Matsumoto et al.	250/325
3,811,048	5/1974	Matsumoto et al.	250/324

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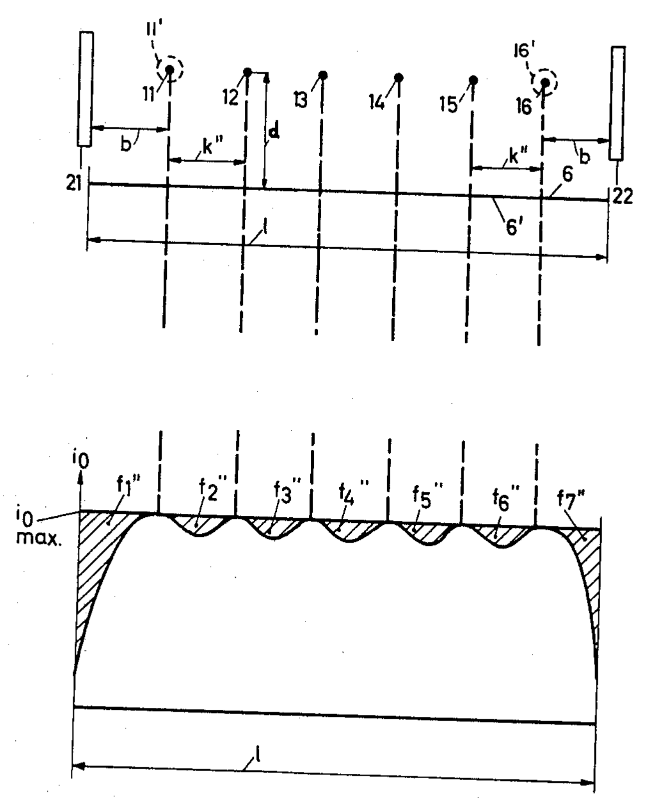
Attorney, Agent, or Firm—Arnstein, Gluck, Weitzenfeld & Minow

[57] **ABSTRACT**

The disclosure describes a charging device including an areal first electrode, a second electrode extending over a given area which is a corona electrode and has several individual electrodes and a source of voltage associated with the two electrodes. The charging device has field-correction means in order to adapt the breakdown voltages of the individual electrodes to adjacent conductive parts not lying at the potential of the corona electrode, in order to obtain both a uniform, high charge-current density as well as a high total charge current. The combination of both a uniform, high-charge, current density and a high total charge current provided by the charge device permits a substantial shortening of the time of the charging process.

13 Claims, 10 Drawing Figures



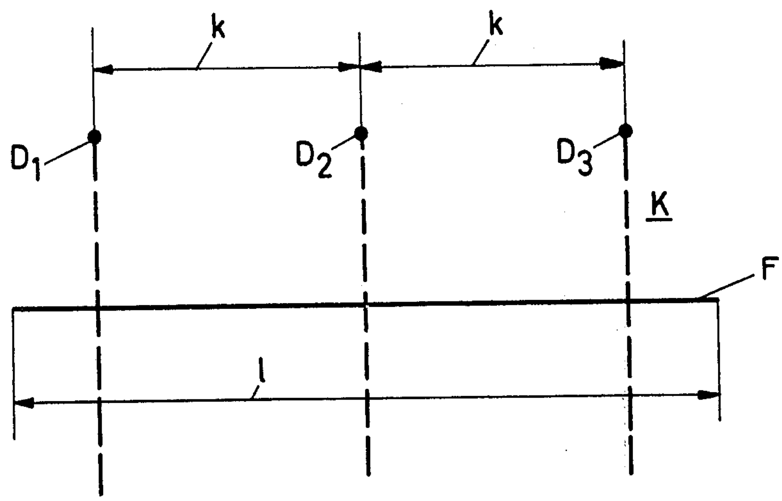


Fig. 1

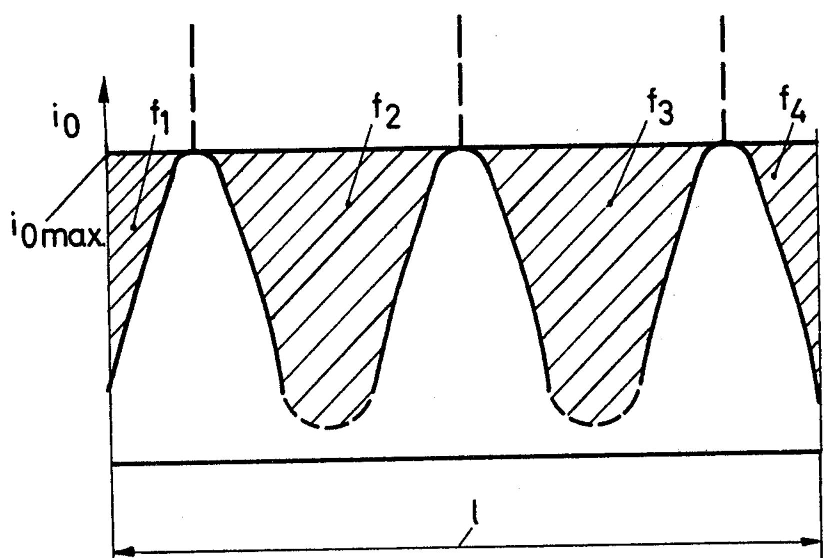


Fig. 2

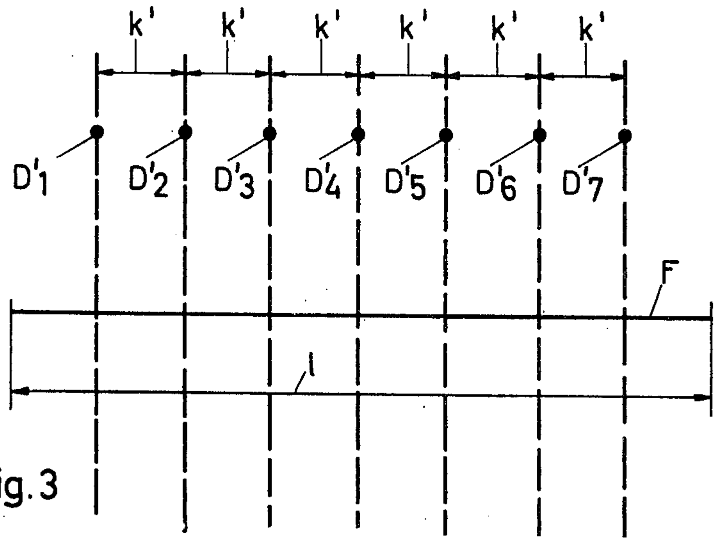


Fig. 3

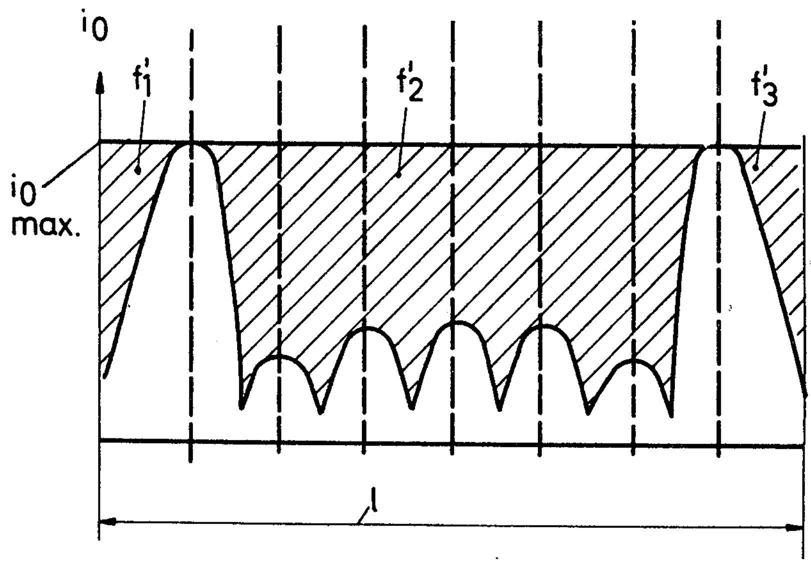
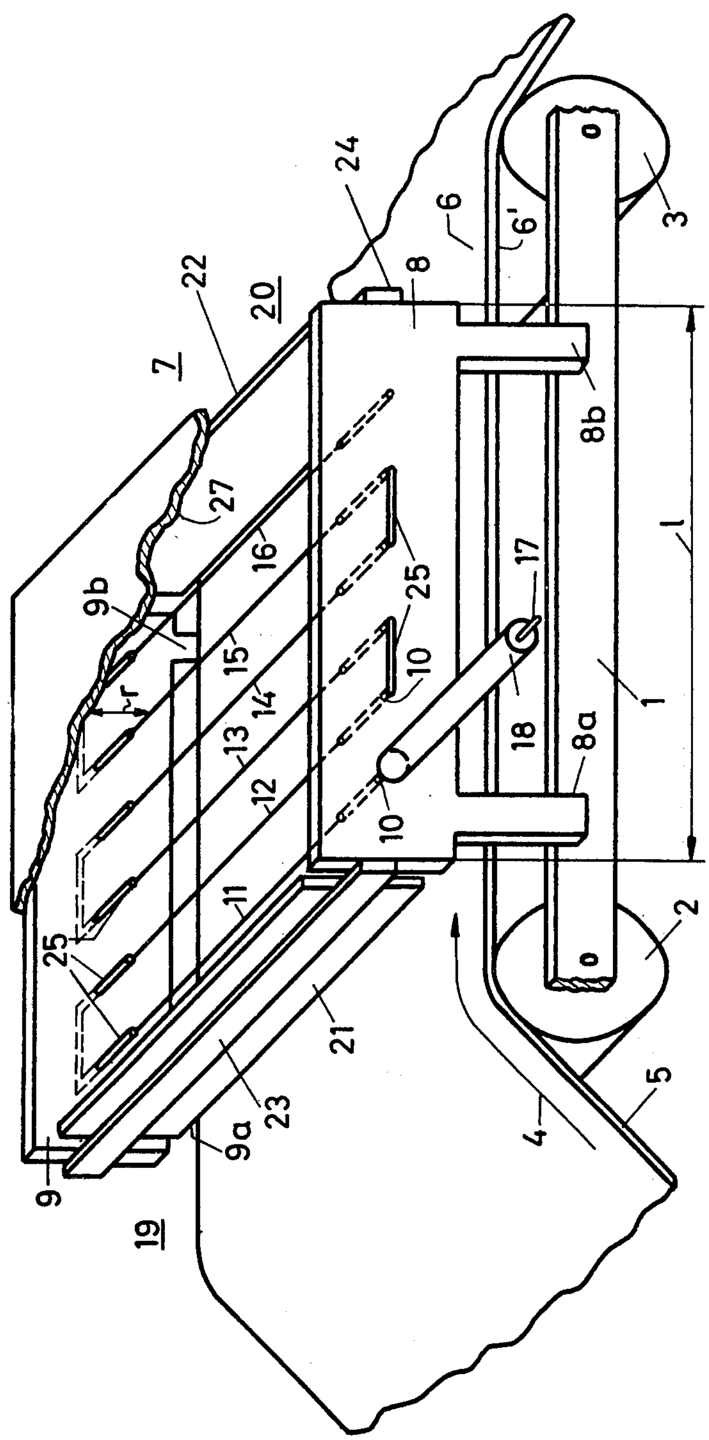


Fig. 4


1
2
3
4
5
6
6'
7
8
8a
8b
9
9a
9b
10
11
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16
17
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20
21
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23
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25
27
r
l

Fig.5

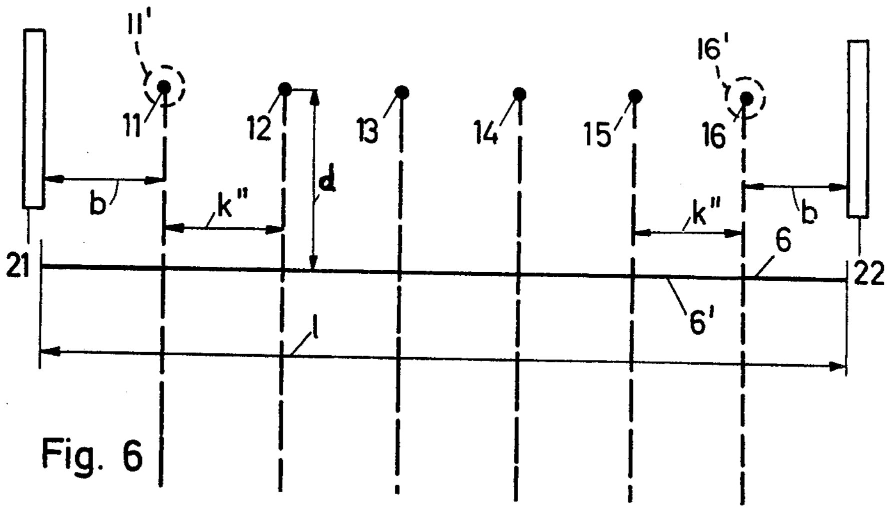
11'
11
12
13
14
15
16'
16
d
b
k"
k"
b
21
6
22
6'
l

Fig. 6

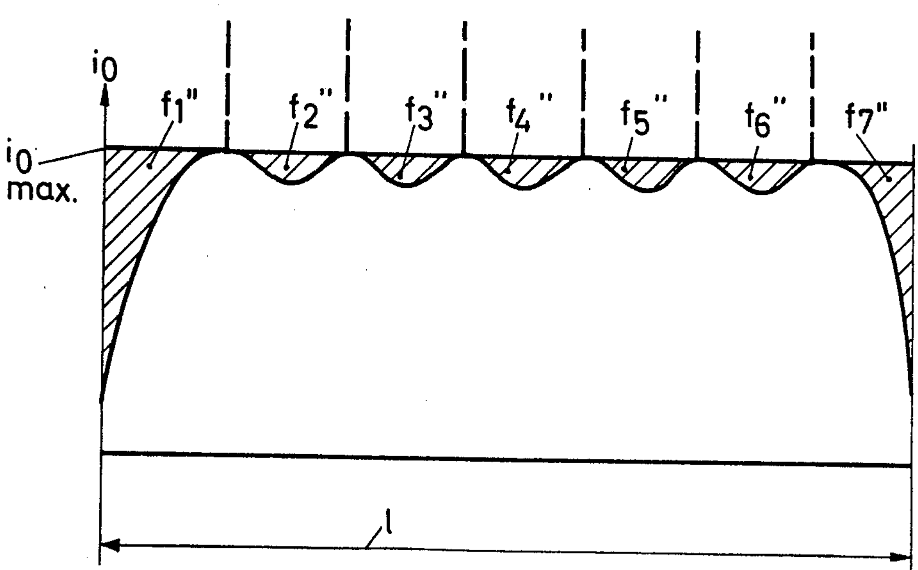
i_0
i_0 max.
f_1''
f_2''
f_3''
f_4''
f_5''
f_6''
f_7''
l

Fig.7

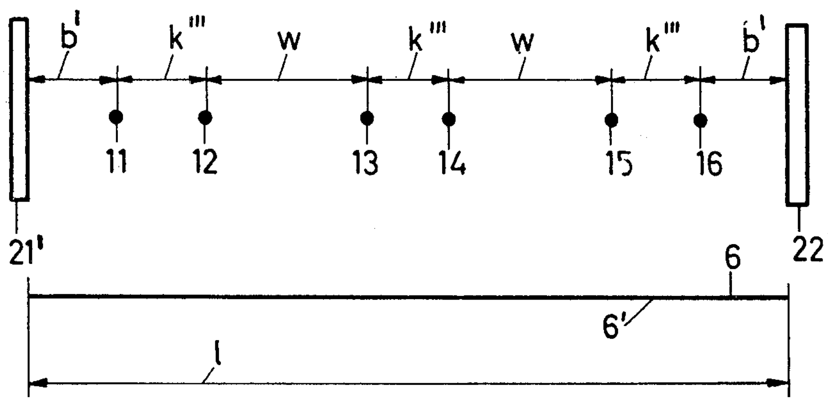

Fig. 8

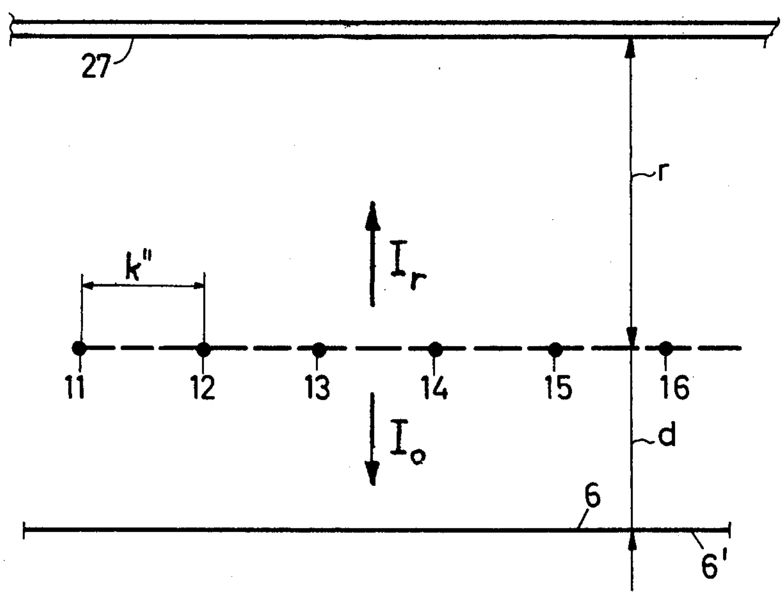

Fig. 9

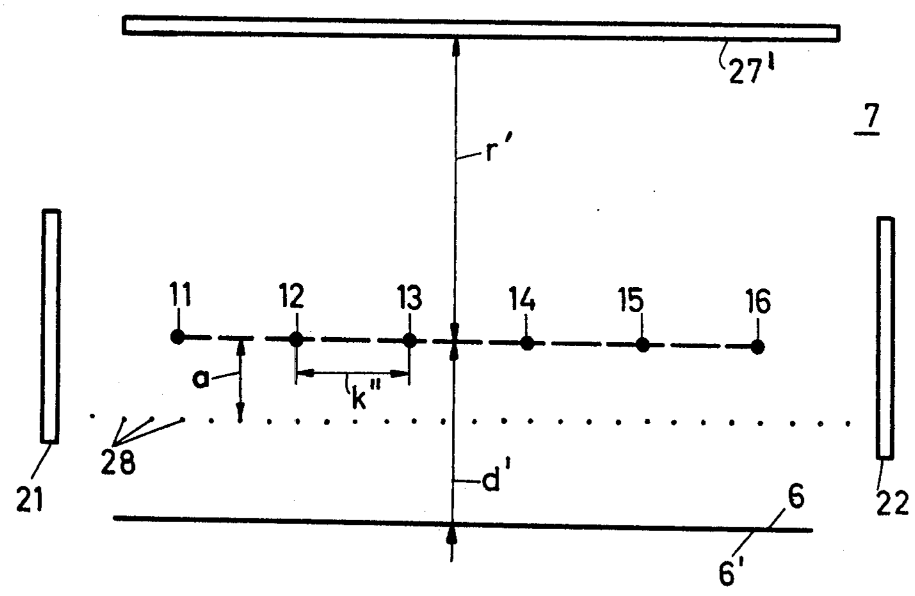

Fig. 10

CHARGING DEVICE

The present invention relates to a charging device. The invention refers in particular to a charging device for the electrostatic charging of a charge carrier of an apparatus for the electrographic or electrophotographic production of images.

In such apparatus it is customary to charge a charge carrier, for instance a sheet of paper, bearing a known ZnO-containing coating, to a voltage of, for instance, a few hundred volts and then by selective exposure producing an electrostatic charge image which depends on an original.

The duration of the operating cycle of such an apparatus for the production of images and thus its operating speed depends also on the period of time which is required for the charging of a given area, for instance a sheet of size **A4**, to a given voltage. In order now to be able to accelerate the operating speed of such apparatus as compared with the values customary today, the performance properties of the charging device operating, for instance, as a corona device must be considerably increased. There has been no lack of attempts to achieve this purpose but no essential improvement could be obtained up to now. The most obvious idea of simply increasing the voltage at the corona electrode could not heretofore be carried out in practice since voltage breakdowns occurred to adjacent conductive parts which are not at the potential of the corona electrode.

The object of the present invention is therefore to create a charging device which permits a substantial shortening of the time of the charging process, referred to a given area. For this purpose a high charge-current density i_o as well as a high total charge current I_o are required. The method of achieving this purpose concerns on the one hand the dimensioning of the corona electrode and on the other hand the use of field-correction means at the corona electrode and in its vicinity.

The present invention relates to a charging device consisting of an areal first electrode developed to receive a charge carrier, a second electrode extending over a given area which is developed as a corona electrode and has several individual electrodes, and of a source of voltage associated with the two electrodes, the charging device being characterized by the fact that it has field-correction means in order to adapt the breakdown voltages of the said individual electrodes to adjacent conductive parts not lying at the potential of the corona electrode, to each other in order thereby to obtain both a uniform, high charge-current density i_o as well as a high total charge current I_o.

The invention will be described by way of example below with reference to the accompanying drawing in which:

FIG. **1** is a schematic showing of a first charging device.

FIG. **2** shows the course of the current in an arrangement in accordance with FIG. **1**.

FIG. **3** is a diagrammatic showing of a second charging device.

FIG. **4** shows the course of the current of an arrangement in accordance with FIG. **3**.

FIG. **5** is a perspective view of one embodiment of the present invention.

FIG. **6** is a diagram of the charging device of FIG. **5**.

FIG. **7** shows the course of the current in an arrangement in accordance with FIGS. **5** and **6** respectively.

FIG. **8** is a diagram of a charging device with corona wires arranged in pairs.

FIG. **9** is a diagram of a charging device with conductive lid.

FIG. **10** is a diagram of a charging device with control electrode.

In all figures, corresponding parts are provided with the same numbers. The figures have not been drawn to scale.

Before describing the examples of the invention, in order to assure a better understanding thereof, reference will be had to a few difficulties which occur in known arrangements and which stand in the way of a faster charging. In order to charge a given area to a given potential in the shortest possible time, it is known to use several corona wires rather than only a single one. See, for instance, Shaffert, The Role of Corona Charging in Electrophotography, Pre-Prints Int. Cong. Phot. Sci. ICPS Moscow 1970, E II, 45.

In order to achieve the desired goal, namely rapid charging to a given potential, there is required not only a high charge-current density i_o, but also a high total charge current I_o towards the coating (FIG. **9**).

It is in itself obvious to use a corona voltage which is as high as possible. However, the corona voltage is limited by the breakdown voltage at which the maximum current density is given off. The operating voltage of the corona electrode must now be selected sufficiently below its breakdown voltage. The breakdown voltage is not a constant value for a given corona arrangement, but is rather dependent on various parameters, for instance the air pressure, the humidity of the air, etc. In order to assure dependable operation, the actual operating voltage U of a corona system must therefore be selected, for instance, 10% lower than the breakdown voltage U_D under normal conditions.

In order, however, to be able to solve the object forming the basis of the present invention, it is necessary to take measures to achieve both the highest possible charge-current density i_o to the surface to be charged and the highest possible total charge current I_o. However, since the charge-current density is limited, the charging device must extend over a relatively large area and it must give off a charge-current density which is as high and uniform as possible to said entire area.

It is already known to use multi-wire corona systems for this purpose, but detailed investigations have shown that special factors must be taken into account with regard to the distribution in space of the individual wires if optimum results are to be obtained (see in this connection also the literature cited above).

FIG. **1** shows a diagram of a first corona system K and the area F to be charged. Here three corona wires D_1, D_2 and D_3 arranged at a relatively large distance apart k are provided.

FIG. **2** shows the variation of the current which can be obtained with a system in accordance with FIG. **1**. It should be noted that as a result of the relatively large spacing *k*, *a* charge-current density i_o which lies approximately at the value $i_{o\ max}$ is present only in the immediate vicinity of the individual corona wires D_1, D_2 and D_3, while in the zones between the individual corona wires, only a relatively low charge-current density is obtained. The areas f_1, f_2, f_3 and f_4 which are hatched in FIG. 2 are a measure of the deficit of charge-current density which occurs as a result of the selected arrangement of the corona wires.

The showing of FIG. 2 makes it now obvious to select a corona arrangement in which the individual corona wires are arranged at a substantially smaller distance apart.

FIG. 3 shows another corona system in which 7 corona wires $D'_1 \ldots D'_7$ are arranged over the length l, the distance between two consecutive corona wires being reduced as compared with the arrangement of FIG. 1 to the value k'.

Similar to FIG. 2, FIG. 4 again shows the variation of the current of the corona arrangement of FIG. 3. Surprisingly the expected result, namely a charge-current density which is as uniform as possible over the entire length is not obtained. Rather it is found that the high charge-current density $i_{o\ max}$ occurs only at the two outermost corona wires D'_1 and D'_7, while the other corona wires arranged between the two outermost corona wires produce only a very low charge-current density. The deficit of charge-current density represented by the area f'_1, f'_2 and f'_3 could thus not be eliminated solely by the use of a larger number of corona wires and a smaller spacing between them.

If one were to increase the corona voltage in order to reduce the area f'_2 which represents the greater part of the said deficit, then a voltage breakdown would occur at the outermost corona wires D'_1 and D'_7.

It has now been found that the said voltage breakdown can be prevented by field-correction means. The unfavorable course of the curve of i_o along the length 1 can be improved by the said field-correction means. During the further course of this specification, a number of different field-correction means will be described which, used alone or in combination, result in a substantial increase in the speed of charging due to a more favorable shape of the i_o curve and/or due to a higher total charge current I_o. Since it has been found that the voltage breakdowns upon an increase in the corona voltage U occur first of all at the edge regions of the corona electrode, the objct of the said field-correction means is so to affect the course of the field in these regions that the breakdown voltage U_D is as far as possible the same everywhere and at all parts of the corona electrode and thus all parts (wires) can be operated with the maximum charge-current density.

FIG. 5 shows a perspective diagrammatic view of an embodiment of a charging device in accordance with the present invention. Such a charging device can, for instance, be used in an electrostatic copier for the charging of a photoconductor which is thereupon exposed in accordance with an original copy in order to obtain a latent electrostatic charge image. Such a latent electrostatic charge image can either be developed on the photoconductor itself in known manner or else it can be transferred to another support by the well-known charge-transfer process. Another possible use of such a charging device consists in electrostatically charging with it insulating layers, for instance individual sheets of paper, so that they will be held fast by the electrostatic forces then occurring on a transport device, for instance a Mylar conveyor belt, as a result of electrostatic forces of attraction.

FIG. 5 shows a portion from an apparatus having a charging device in accordance with the present invention. Two rollers 2 and 3 rotatably supported in a chassis frame 1. A carrier 5 for the receiving of an electrostatic charge travels over said rollers 2 and 3 in the direction indicated by the arrow 4. The carrier 5 can, for instance, be a highly insulating Mylar belt on the surface 6 of which an electric charge is to be applied. A charging device 7 is provided for the application of this charge. The charging device 7 has two lateral supporting walls 8 and 9, the supports 8*a* and 8*b* and 9*a* and 9*b* respectively of which rest on the chassis frame 1. The chassis frame 1 has been merely indicated in the drawing. The supporting walls 8 and 9 consist of high-quality insulating material. It is particularly advantageous to use for this purpose corona-resistant insulating material such as, for instance, polytetrafluorethlene or Plexiglas. A thin wire having a diameter of, for instance, 0.1 mm is passed several times through a number of bore holes 10 in supporting walls 8 and 9 between said walls 8 and 9. In this way there is obtained an arrangement of parallel wires 11 . . . 16 which are stretched at a uniform distance apart over the surface 6 of the carrier 5.

The end of the said wire which emerges through the first opening 10 is connected with the conductor 17 of a high-voltage cable 18. The high-voltage cable 18 leads to a pole of a source of voltage (not shown) for the corona voltage U which is, for instance, 13 kv. The other pole of the source of voltage is preferably connected with the chassis frame 1 or with ground. The rollers 2 and 3 are made of conductive material so that the bottom 6' of the carrier 5 assumes the potential of the chassis frame 1. The bottom 6' of the carrier 5 can, for instance, be metallized at least in the region in which its surface is to be charged, thus forming a grounded electrode.

If the high-voltage source is connected to the corona electrode, the continuous carrier 5 is charged electrostatically on its surface 6 by said charging device 7. Insofar as the arrangement of FIG. 5 has been described up to this point, it corresponds in principle to FIG. 3, and the course of the charge-current density i_o will correspond to FIG. 4. In the case of the charging device 7 of FIG. 5, however, field-correction means 21 and 22 respectively are arranged on the front side 19 (i.e. entrance side of the carrier 5) as well as on the rear side (20) i.e. exit side of the carrier 5) respectively. As field-correction means 21 and 22, there are preferably provided separate insulating boards supported by a carrier 23 and 24 respectively on the supporting walls 8 and 9. This insulating board consists preferably of a corona-resistant insulating material such as polytetrafluorethylene. The course of the field at the edge of the corona electrode which is formed from the corona wires 11–16 is so favorably affected by these insulating boards which act as field-correction means 21 and 22 respectively that practically the same breakdown voltage U_D is obtained for all of these wires; in other words, in this way, approximately the same charge-current density i_o is also obtained for all of these wires.

FIG. 6 shows schematically the construction of the charging device of FIG. 5, and FIG. 7 shows the course of the charge-current density i_o along the length 1 of the area to be charged which is obtained with this charging device. It can be readily seen that the entire hatched area $f''_1 = f''_7$ which represents the deficit of charge-current density is substantially less in FIG. 7 than it is in FIG. 4 which correponds to a charging device without field-correction means. Such a field-corrected charging device has the result that the same field distribution and thus the same breakdown voltage U_D is present as far as possible at all corona wires 11–16 and they can thus all be operated with the same maximum operating voltage and all give off the optimum charge-current density; while without field-correction, a disturbing marginal field occurs at the outermost corona wires (FIGS. 3 and 4), reducing U_D, so that then only these outermost corona wires give off a high charge-current density i_o.

The field-correcting limiting elements **21, 22** can consist, for instance, of corona-resistant insulating boards, struts, bar grids or nettings which form essentially insulating surfaces which are charged by the corona electrode and therefore act to correct the field. For this purpose, the distance b from these limiting elements to the outermost corona wires as well as the distance d of the corona wires from the surface **6** should be approximately the same as the distance k'' of the corona wires from each other — $b \approx k'' \approx d$; k''/b and k''/d should preferably be between 0.7 and 1.5.

With such field-corrected, multi-wire corona devices one can, for instance, obtain an increase in the total charge current I_o of two to five times, with corresponding reduction of the charging time, as compared with similar devices without field-correction means.

It can thus be seen that by the use of such field-correction means, the object of the invention, namely a faster charging of an area to be charged, is achieved both by the more uniform course of the i_o curve and by the higher total charge current I_o.

For further improvement, insulating sleeves **25** can be placed on the ends of the corona wires **11 . . . 16** and on the parts of said wires extending along the outer sides of the supporting surfaces **8** and **9** as further field-correction means. These insulating sleeves **25** also represent field-correction means.

It has furthermore been found that an arrangement of the corona wires **11 . . . 16** in pairs, the distance between the wires **11** and **12**, **13** and **14** and **15** and **16** being selected smaller than the distance between the wires **12** and **13** and **14** and **15**, also gives an improvement with respect to the uniform course of the charge-current density along the length **1**.

FIG. **8** shows schematically the construction of a charging device with corona wires **11 . . . 16** arranged in pairs. The first pair is formed by corona wires **11** and **12**, the second pair by corona wires **13** and **14**, and the third pair by corona wires **15** and **16**. The distance k''' between the two wires of a pair is less than the inside distance w between the adjacent wires of two pairs. The distance b' from the limiting element **21'** and **22'** is preferably approximately equal (and even larger in the case of conductive limiting elements) than the inside clearance w.

Another reason for the occurrence of undesired voltage breakdowns, i.e. local reduction of the breakdown voltage U_D, resides in the tendency of highly-stressed corona wires to swing. The largest reduction of U_D then namely also takes place at the place of the large amplitudes of swing.

In this way the uniformity of U_D and thus also of the charge-current density i_o over the entire corona electrode is greatly impaired.

As remedy, field-correction means can be used in this case also:

FIG. **9** shows schematically another advantageous embodiment of the charging device **7**. On the side opposite the corona electrode **11 . . . 16** of the surface **6** to be charged and at a distance r therefrom there is arranged as cover a conductive surface **27** which normally lies at ground potential. In this figure, the total charge-current I_o as well as the portion of the current I_r flowing to the lid are also entered. Field-correction means can now see to it that I_r becomes much smaller than I_o, as a result of which the said swingings of the corona wires are suppressed. In the case of the conductive lid **27**, this is obtained by making r larger than d, preferably $r > 1.5d$.

An even better effect is obtained with a lid of insulating, corona-resistant material: surface **27'** in FIG. **10**, preferably at a distance away $r' \approx d'$.

FIG. **10** shows another advantageous embodiment of the invention. In this variant, a control electrode **28** is arranged in the space between the corona electrode **11 . . . 16** and the surface **6** to be charged. The control electrode **28** consists, for instance, of a large number of parallel wires arranged close together and extending in a plane parallel to the corona electrode formed by the corona wires **11 . . . 16.**

The distance a between the corona electrode **11 . . . 16** and the control electrode **28** is in this correction preferably selected only slightly smaller than the distance d' between corona electrode and area **6** to be charged, for instance $d' - a = 1$–3 mm.

It has furthermore been found that for uses in which in itself no control electrode would be required, it may nevertheless be advantageous to use as additional field-correction means for increasing the total charge current I_o a reduced control electrode which consists of in each case only one control wire per corona wire, in which connection the control wires must extend parallel to the corona wires.

Good results could, for instance, be obtained with the following data:

d = 14 mm	U = 13 kv
k'' = 14 mm	b = 14 mm
a = d = 14 mm	d' = 15–16 mm
k''' = 14 mm	w = 2k'''
r = 24 mm	r' = 14 mm

Another possibility for the correction of the edge field, instead of using the limiting elements **21, 22** in FIG. **6**, consists in making the two outermost wires (**11', 16'**) of the corona electrode so thick (for instance 0.5 – 1 mm) that no corona discharge occurs there as shown in broken lines in FIG. **6**.

I claim:

1. A charging device comprising an areal first electrode adapted to support a charge carrier, a second electrode extending over a given area which is a corona electrode and has several individual corona electrode wires, a source of voltage associated with both electrodes, and field-correction means of insulating material arranged outside of the volume defined by the said area of said corona electrode and the areal first electrode, for adapting the breakdown voltages of the said individual corona electrode wires to adjacent conductive parts not lying at the potential of the corona electrode wires in order thereby to obtain both a uniform, high charge density i_o and a high total charge current I_o.

2. The charging device according to claim **1** wherein said field-correction means is at least one insulating element arranged at an edge of the charging device.

3. The charging device according to claim **2**, wherein said insulating element consists of corona-resistant material at least on a side of the device facing the corona electrode.

4. The charging device according to claim **1** wherein said wires are stretched parallel to each other and said field-correction means comprises a plurality of insulating elements arranged at the edges of the corona electrode and extend parallel to the wires.

5. The charging device according to claim **4,** wherein the distance (b) between the outermost wire of said second electrode and the insulating element adjacent thereto is at least approximately the same as the distance (k'') between the said outermost wire of said second electrode and the second outermost wire of said second electrode adjacent thereto.

6. The charging device according to claim **1,** further having individual electrodes arranged as field-correction means at the edge of the corona electrode which have a greater thickness than the individual electrodes arranged inward thereof.

7. The charging device according to claim **1** wherein said individual corona electrode wires are arranged in pairs and the distance (k''') between two individual electrode wires of a pair is at least approximately equal to the distance (d) of the corona electrode from the first electrode and the inside clearance (w) between the adjacent individual electrode wires of two adjacent pairs is at least approximately twice as great as the distance (k''') between said two individual electrode wires of a pair.

8. The charging device according to claim **1** wherein said field-correction means comprises an insulating surface arranged on the side of the corona electrode facing away from the first electrode.

9. The charging device according to claim **1** wherein a conductive surface is arranged on the side of the corona electrode facing away from the first electrode at a distance (r) from the corona electrode, and the distance (r) is at least 1.5 times as great as the distance (d) of the corona electrode from the first electrode opposite it which does not lie at the potential of the corona electrode.

10. The charging device according to claim **4,** wherein the distance (k'') between the individual corona electrode wires of the second electrode is about 0.7 to about 1.5 times greater than the distance (d) of the second electrode from the first electrode.

11. The charging device according to claim **1,** wherein a third electrode acting as a control electrode is arranged between the first electrode and the second electrode.

12. The charging device according to claim **11,** wherein the control electrode comprises one wire per corona electrode wire, which wires are parallel to each other.

13. The charging device according to claim **12,** wherein said control electrode is arranged at a distance (a) from the second electrode which is only slightly less than the distance (d') between the second electrode and the charge carrier.

* * * * *